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JUN 19 2007
PATENT & TRADEMARK OFFICE

PTO/SB/17 (06-07)
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Effective on 12/08/2004.
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2007

☑ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT	($) 1,370.00

Complete if Known	
Application Number	10/714,230
Filing Date	November 14, 2003
First Named Inventor	SUN, Sam-Shajing
Examiner Name	Hall, Asha J.
Art Unit	1709
Attorney Docket No.	036021.0001

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____________

☑ Deposit Account Deposit Account Number: 50-0766 Deposit Account Name: ____________

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☑ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, except for the filing fee

☑ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☐ Credit any overpayments

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
Application Type	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fees Paid ($)
Utility	300	150	500	250	200	100	
Design	200	100	100	50	130	65	
Plant	200	100	300	150	160	80	
Reissue	300	150	500	250	600	300	
Provisional	200	100	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	50	25
Each independent claim over 3 (including Reissues)	200	100
Multiple dependent claims	360	180

Total Claims	Extra Claims	Fee ($)	Fee Paid ($)
5 - 20 or HP =	x	=	

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims	Extra Claims	Fee ($)	Fee Paid ($)
1 - 3 or HP =	x	=	

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims	
Fee ($)	Fee Paid ($)

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof	Fee ($)	Fee Paid ($)
- 100 =	/ 50 =	(round up to a whole number) x	=	

4. OTHER FEE(S) Fees Paid ($)

Non-English Specification, $130 fee (no small entity discount)

Other (e.g., late filing surcharge): Petition for Exceptance of Unintentionally Delayed Claim for Priority $1,370

SUBMITTED BY

Signature	[signature]	Registration No. (Attorney/Agent) 43,659	Telephone 757-499-8800
Name (Print/Type)	M. Bruce Harper		Date June 19, 2007

PTO/SB/21 (04-07)
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/714,230
Filing Date	November 14, 2003
First Named Inventor	SUN, Sam-Shajing
Art Unit	1709
Examiner Name	Hall, Asha J.
Attorney Docket Number	036021.0001
Total Number of Pages in This Submission	

ENCLOSURES *(Check all that apply)*

- [x] Fee Transmittal Form
  - [ ] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [x] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ________
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC (Appeal Notice, Brief, Reply Brief)
- [ ] Proprietary Information
- [ ] Status Letter
- [x] Other Enclosure(s) (please Identify below):

Return Postcard
Certificate of Express Mailing

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Williams Mullen		
Signature	[signature]		
Printed name	M. Bruce Harper		
Date	June 19, 2007	Reg. No.	43,659

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	Sharon L. Hardee		
Typed or printed name	Sharon L. Hardee	Date	June 19, 2007

6-20-07

DAC
ZW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Sam-Shajing SUN	Confirmation No.: 2469
Application No. 10/714,230	Art Unit: 1709
Filed: November 14, 2003	Examiner: Asha J. Hall
For: PHOTOVOLTAIC DEVICES BASED ON A NOVEL BLOCK COPOLYMER	Attorney Docket No: 036021.0001

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PETITION FOR THE ACCEPTANCE OF UNINTENTIONALLY DELAYED CLAIM FOR PRIORITY UNDER 37 CFR § 1.78(a)

Dear Sir/Madam:

Applicant hereby petitions for the acceptance of the unintentionally delayed claim for priority under 37 CFR 1.78(a) for the above-referenced pending application. The above referenced pending application was filed with a priority claim referencing a provisional patent application, but this reference included a typographic error in the serial number of such reference (i.e., the incorrect reference to U.S. Provisional Patent Application Ser. No. 60/42**8**,108, wherein the underscored **8** should have been a **6**). This typographic error of a single digit was identified upon examination. At no time did Applicant intentionally delay correction of such priority claim; the entire delay was unintentional. In summary, Applicant intended to claim priority to U.S. Provisional Patent Application Ser. No. 60/426,108. With the Commissioner's acceptance, the Applicant intends to amend the above referenced application with such a correction.

This petition is accompanied by a priority claim reference to the prior-filed provisional application, U.S. Provisional Patent Application Ser. No. 60/426,108, in

06/21/2007 HVUONG1 00000010 500766 10714230
01 FC:1454 1370.00 DA

Attachment A. A copy of the U.S. Provisional Patent Application Ser. No. 60/426,108 is provided in Attachment B.

The Commissioner is therefore respectfully requested to accept this correction of the priority claim of the referenced pending application. A fee of **$ 1,370** is believed to be due for this petition. Please charge the required fee to Williams Mullen Deposit Account No. 50-0766.

Respectfully submitted,
WILLIAMS MULLEN

Date: June 19, 2007

M. Bruce Harper (Reg. No. 43,659)

Customer Number: 45309
(757) 499-8800

Attachment A

The present application claims priority from U.S. Provisional Patent Application Ser. No. 60/426,108, filed November 14, 2002, which is hereby incorporated by reference.

Attachment B

P1 1113515

RECEIVED
15 JAN 2004
WIPO PCT

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

January 12, 2004

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *60/426,108*
FILING DATE: *November 14, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/36538*

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

T Lawrence

T. LAWRENCE
Certifying Officer

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

11-15-02 60426108 .111402 A/1

11/14/02 JC715 U.S. PTO

JC973 U.S. PTO 60/426108 11/14/02

SUBSTITUTE FOR PTO/SB/16 (2-98)

Please type a plus sign (+) inside this box → [+]

Approved for use through 01/31/2001. OMB 0651-0037
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

INVENTOR(S)		
Given Name (first and middle[if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Sam-Shajing	Sun	427 Willow Brook Way Chesapeake VA 23320

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

A Photovoltaic Device Based on Conjugated Block Copolymers

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☒ Customer Number 43659 → *Place Customer Number Bar Code Label here*

Type Customer Number here

OR

☒ Firm or Individual Name	M. Bruce Harper				
Address	Williams Mullen				
Address	One Columbus Center, Suite 900				
City	Virginia Beach	State	VA	ZIP	23462
Country	USA	Telephone	757-473-5357	Fax	757-473-0395

ENCLOSED APPLICATION PARTS (*check all that apply*)

☒ Specification *Number of Pages* 9 ☐ Small Entity Statement

☒ Drawing(s) *Number of Sheets* 3 ☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (*check one*)

☒ A check or money order is enclosed to cover the filing fees

☐ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-0766

FILING FEE AMOUNT($): 75.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ______

Respectfully submitted,

Date 11/14/02

SIGNATURE [signature]

TYPED or PRINTED NAME M. Bruce Harper

TELEPHONE 757-473.5357

REGISTRATION NO. 43659 (if appropriate)

Docket Number: 036021.0001

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

60426108.111402

SUBSTITUTE FOR PTO/SB/17 (2-98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL

Patent fees are subject to annual revision on October 1.
These are the fees effective October 1, 1997.
Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See forms PTO/SB/09-12. See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT 75.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Sun, Sam-Shajing
Examiner Name	
Group / Art Unit	
Attorney Docket No.	036021.0001

METHOD OF PAYMENT (check one)

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number	50-0766
Deposit Account Name	Williams Mullen

☒ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance

2. Payment Enclosed: Check ☒ Money Order ☐ Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	760	201	380	Utility filing fee	
106	310	206	155	Design filing fee	
107	480	207	240	Plant filing fee	
108	760	208	380	Reissue filing fee	
114	150	214	75	Provisional filing fee	75.00
				SUBTOTAL (1)	($)75.00

2. EXTRA CLAIM FEES

		Extra Claims		Fee from below		Fee Paid
Total Claims	-**=	0	X		=	
Independent Claims	-**=		X		=	
Multiple Dependent					=	

**or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($)

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	380	216	190	Extension for reply within second month	
117	870	217	435	Extension for reply within third month	
118	1,360	218	680	Extension for reply within fourth month	
128	1,850	228	925	Extension for reply within fifth month	
119	300	219	150	Notice of appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive – unavoidable	
141	1,210	241	605	Petition to revive – unintentional	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	760	246	380	Filing a submission after final rejection (37 CFR 1.129(a))	
149	760	249	380	For each additional invention to be examined (37 CFR 1.129(b))	
Other fee (specify)				Late filing fee/declaration surcharge	
Other fee (specify)					

*Reduced by Basic Filing Fee Paid **SUBTOTAL (3)** ($)

SUBMITTED BY

			Complete (if applicable)	
Typed or Printed Name	M. Bruce Harper		Reg. Number	43659
Signature	[signature]	Date 14 NOV 02	Deposit Account User ID	50-0766

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office,

60426108.111402

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EJ047666794US	14 NOV 02
"Express Mail" label number	Date of Deposit

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Box PROVISIONAL PATENT APPLICATION, Assistant Commissioner for Patents, Washington, D.C. 20231.

Signature of person mailing correspondence

M. BRUCE HARPER

Typed or printed name of person mailing correspondence

Note: Each paper must have its own certificate of mailing by "Express Mail".

036021.0001
Title: A Photovoltaic Device Based on Conjugated Block Copolymers
Inventor: Sam-Shajing Sun

A Photovoltaic Device Based on Conjugated Block Copolymers

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to the field of photovoltaic or opto-electronic devices. More particularly, this invention relates to cost effective, lightweight, and flexible shaped "plastic" photo detectors and "plastic" solar cells (renewable and clean energy generation), etc.

Background

Photovoltaic (PV) is a process where light is absorbed by a media and is then converted into a voltage or electric current. When light strikes certain materials, the photons in the light excite electrons in the material. In some materials, there are free electrons that are released by the interaction with the photon; the movement of that electron leaves a hole. The flow of the electron, along with the resulting holes creates electric current. Most of the PV cells used today are based on inorganic semiconductor materials such as silicon, although other materials, such as Gallium Arsenide, Cadmium Telluride, Copper Indium Diselenide are also used.

The typical silicon based solar cell uses a semiconductor pn-junction. The cell comprises semiconductor layers, one of which is n-doped (doped with atoms of excess valence electrons) and the other is p-doped (doped with atoms lacking a valence electron); their interface forms a pn-junction. The n-doped layer is characterized by

excess electrons, while the p-doped layer is characterized by holes. In other words, the n-doped layer is a donor (D) of electrons, and the p-doped layer is an acceptor (A). Initially the doped materials reach equilibrium across the pn-junction. When sunlight strikes the material, the light is absorbed in the excitation of the excess electrons, which are released and create a charge separation along the pn-junction; a transport of electrons and holes creates the electrical current that is collected by electrodes.

The high cost of manufacturing traditional inorganic photovoltaic materials and devices has led to significant research into alternative photovoltaic materials, as well as how to configure those materials within the solar cells. Additionally, improved efficiency could lower the lifetime cost and make photovoltaic devices a more commercially attractive and environmentally friendly energy alternative. One area of research is the use of organic materials to fabricate solar cells, such as using semi-conducting conjugated polymers, liquid crystalline structures, etc. Organic materials, including polymers, are relatively inexpensive, lightweight, flexible, and easily manufactured in comparison to their inorganic counterparts.

However, semi-conducting polymers work differently from inorganic semiconductors. Semi-conducting polymers are long molecules that have repeating structures and with alternating single and double carbon-carbon bonds, and are referred to as being "conjugated." The double bonds (also called π bonds) within conjugated polymers generate a highest occupied molecular orbital (HOMO) that is typically filled with π electrons, and a lowest unoccupied molecular orbital (LUMO) that is typically

empty without light or other forms of excitation. The HOMO or LUMO of each double bond in a conjugated polymer backbone interact with each other and form HOMO and LUMO bands, the energy difference between the two bands is generally called band gap, or sometimes also called the "optical gap".

Most conjugated polymers appear to have a band gap that lies in the range of 1–3 eV, which makes them ideally suited for light harvesting or photovoltaic devices working in the visible light range. The photo-induced electron transfer and charge (electron-hole) separation observed in conjugated organic composites of the donors (electron-donating or p-type organic species) and acceptors (electron-withdrawing or n-type organic species) provide an alternative to traditional inorganic solar cells.

The mechanism for an organic approach to high efficiency light harvesting or photovoltaic conversion has been developed. Specifically, in organic photovoltaic materials, for instance, light generated excitons (*e.g.*, electron-hole pairs) can typically diffuse 20 nm in their lifetime. The charges (electrons and holes) can be separated at the contact interface between the donors and acceptors, where for donor excitons, the electrons are transferred from donor's LUMO to the acceptor's LUMO and for acceptor excitons, the holes transferred from acceptor's HOMO to the donor's HOMO, provided that the corresponding energy level differences between the donor and acceptor are big enough to overcome the exciton binding energy (typically 0.5 eV). Next, and mainly due to the asymmetry of the photovoltaic cell, the electrons travel and are collected at the negative electrode, and holes travel and are collected at the positive electrodes. One of

the main scientific challenges for a high efficiency organic photovoltaic device is to fabricate a nano structure where both the donor and acceptor phases have dimensions within the typical organic exciton diffusion range (about 20 nm), yet are continuous between the two electrodes.

DESCRIPTION OF THE INVENTION

The present invention is a potentially efficient organic photovoltaic device made of a –DBA- or an analogous block copolymer system, where D is a donor derivatized conjugated polymers, oligomers, or equivalent (also referred as "conjugated donor block"), A is an acceptor derivatized conjugated polymer, oligomer, or equivalent (also referred as "conjugated acceptor block"), B is a non-conjugated (such as aliphatic) bridge unit. The said block polymer system may also be embodied in, refer to, or be represented as –ABD-, –DBAB-, -ABDB-, -BDBA-, -BABD-, -DBABD-, -ABDBA-, etc.

The present invention comprises the structure and fabrication process of a polymer or "plastic" thin film photovoltaic device that possesses benefits of lightweight, flexible shape, cost effectiveness, and potentially very high power conversion efficiency in comparison to current commercial inorganic semi-conductor based photovoltaic devices. This "plastic" photovoltaic device has the following features:

1) A conjugated donor block (D) is covalently connected with a conjugated acceptor block (A) via a short non-conjugated bridge unit (B) to form a –DBA- or its analog type block copolymer chemical structure, as shown in Figure 1. Preliminary experimental

work has shown the –DBAB- type to be a useful embodiment. Those skilled in the art will readily see that a variety of configurations could be produced for specific applications or specifications. Preferably, the donor and acceptor blocks should be chosen, configured, or built in such a way that the band gap of both donor and acceptor phases in solid states substantially match the optical radiation energy of the intended applications or devices. This –DBA- and its analog type polymer backbone structure or "Primary Structure" can be realized via common organic design and synthesis.

2) Additionally, both the donor and acceptor conjugated block backbones may be self-assembled in a solid thin film state to form a π-orbital stacked or adjacent block chain closely packed structures, as shown in Figure 2, as in many conjugated polymer systems, so that the π-orbitals between adjacent backbones are well coupled or overlapped to each other. This may be called a "Secondary Structure".

3) Additionally, the donor and acceptor block should be sufficiently different from each other, so that in solid thin film state, donor and acceptor blocks will be able to phase separate from each other as seen in many block copolymer systems. The donor and acceptor separated phases may be self-assembled to form a columnar or "Honeycomb" shaped structures, as is the general case known in many di- or tri-block copolymer systems.

It is known that the incompatibility between the blocks leads to the formation of many unique micro- or nano-phase separated and ordered structures, including, but not limited to, lamella, columnar, cubic centered lattice, etc., and a specific phase separated structure is determined by chemical composition, size of each block, temperature, and other factors. For instance, a recent report of MEH-PPV/Polystyrene-C_{60} donor/acceptor di-block copolymer system indeed exhibited a "honeycomb" shaped nano structure.

Each donor phase column should interface with at least one acceptor column, and vice versa. The diameter of each column should be approximately within the corresponding effective exciton diffusion length of the respective donor or acceptor blocks (typically about 20 nm).

Finally, a thin layer of donor block may be coated on one side of the columnar or "Honeycomb" structure in perpendicular to the column direction in order to form a positive side of the photovoltaic device, and a thin layer of acceptor block will likewise coated on the other side of the "Honeycomb" to form a negative side of the PV device. Other forms of aligning or directing charge as is known in the art will serve as well. Finally, a conducting electrode with a work function close to, or substantially appropriate to the HOMO levels of the donor placed in contact to the donor (positive) layer side of the device will collect holes, and a conducting electrode with a work function close to, or substantially appropriate for the LUMO levels of the acceptor placed in contact to the acceptor layer (negative) side to collect electrons. At least one electrode should be

transparent to the intended light radiation. This may be called "Tertiary Structure" of the said PV cell, as shown in Figure 3.

In the present invention, a –DBAB- type block copolymer system has already been synthesized and characterized recently, where D is an alkyloxy donor derivatized poly-(1,4)-phenylenevinylene (PPV), abbreviated as "RO-PPV", A is a sulfone acceptor derivatized PPV, abbreviated as "SF-PPV-I", and B is a non-conjugated aliphatic bridge unit. Preliminary electron microscopic study has revealed interesting regular nano-phase separated morphological pattern in a drop dried –DBAB- film. A donor or acceptor derivatized polythiophenes, or other similar type materials, may also be used as the conjugated blocks. A non-conjugated bridge unit provides an energy barrier between the bands of the donor and acceptor blocks in order to prevent a convenient electron-hole recombination. The bridge also makes the donor or acceptor rigid blocks less vulnerable to distortion, and more convenient to self-assemble. Conjugated π orbital distortion due to molecular thermal vibrations or backbone twist typically interrupts conjugation and therefore reduces charge mobility.

In summary, the backbone structure –DBA- and its analogs may be called a "Primary Structure". Since the π orbital overlap between rigid blocks are useful for charge mobility, this self-assembly morphology between blocks could be called a "Secondary Structure". Finally, the block copolymer "honeycomb" morphology provides

smooth "tunnels" for charge transportation to the respective electrodes. The "honeycomb" structure may be sandwiched between a thin layer of donor film (in contact with a positive electrode), and a thin layer of acceptor film (in contact with a negative electrode) so that an efficient asymmetric polymeric photovoltaic device is thus formed. The sandwiched "honeycomb" structure can be called a "Tertiary Structure". Another advantage of this system is that the interfacial area and the phase size can be tuned via block copolymer segment size, therefore, the opto-electronic conversion efficiency can be easily optimized via materials design and synthesis.

CLAIMS

What is claimed is:

1. A photovoltaic primary structure comprising:

   a conjugated donor block,

   a conjugated acceptor block, and

   a non-conjugated bridge covalently coupling said donor block and said acceptor block.

2. The photovoltaic primary structure as described in claim 1, wherein a second non-conjugated bridge is covalently coupled to one of either said acceptor block or said donor block, and said second non-conjugated bridge is capable of coupling to other such photovoltaic primary structures to form a repeating chain.

3. A photovoltaic secondary structure comprising a plurality of primary structures in a π orbital stack and closely packed morphology.

4. A photovoltaic tertiary structure comprising a plurality of secondary structures in a phase separated collumnar nano-structure.

5. A photovoltaic tertiary structure as described in claim 4, further comprising a donor thin layer at a first end of such collumnar nano-structure and an acceptor thin layer at an opposing second end of such collumnar nano-structure, wherein said donor thin layer and said acceptor thin layer are oriented to such collumnar nano-structure so as to form an asymmetric geometry.

6. A process for producing a photovoltaic primary structure comprising the steps of

producing a conjugated donor block,

producing a conjugated acceptor block, and

covalently coupling said donor block to said acceptor block with a non-conjugated bridge.

#371307 v2

Please type a plus sign (+) inside this box → [+]

SUBSTITUTE FOR PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted With Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	036021.0001
First Named Inventor	Sun, Sam-Shajing
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A Photovoltaic Device Based on Conjugated Block Copolymers

the specification of which (*Title of the Invention*)

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) ______ as United States Application Number or PCT International

Application Number ______ and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a) -(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION - Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the Untied States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

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As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*
OR
☒ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
M. Bruce Harper	43659		

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☒ Correspondence address below

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])				Family Name or Surname			
Sum-Shajing				Sun			
Inventor's Signature						Date	11/14/2002
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City		State		ZIP		Country	

☐ Additional inventors are being named on the _____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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